Post-Harvest Losses in Legumes and Cereals in Zimbabwe: Levels, Determinants and Mitigation Measures

(PRODUCTION OPTION)

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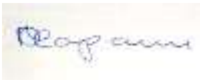
Signed 

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DECLARATION

I hereby declare that the research project entitled "**Post-Harvest Losses in Legumes and Cereals in Zimbabwe: Levels, Determinants and Mitigation Measures**" submitted to the Bindura University of Science Education, Department of Agricultural Economics, Education and Extension is a record of an original work done by me under the guidance and supervision of **Dr L. Musemwa** and **Prof. C. Karavhina**, this work is submitted in partial fulfilment of the requirements for the award of a Master of Science Degree in Food Security and Sustainable Agricultural Production. The results embodied in this thesis have not been submitted to any University or Institute for the award of any degree of diploma.

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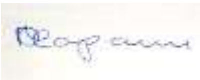
Signature: 

Date: 27 June 2025

DEDICATION

I dedicate this project to my family whose support got me through the process of coming up with this thesis.

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I acknowledge my supervisors for assisting me throughout the project as well as my family for their unwavering support. Above all, I acknowledge the Almighty for His gracious love, strength and the gift of life.

ABSTRACT

Post-harvest loses begin from the onset of harvest in the field and go on to the transformation to the threshing and processing, the storage as well as in the marketing as well as preparation of the food by the final consumer along the supply value chain. This thesis focused on the PHLs in legumes and cereals, the levels and the prospects. The main objective was to determine the levels of PHLs amongst the legume and the cereal value chains. The specific objectives were to determine the magnitude of the PHL, to ascertain the socio-economic characteristics of the respondents as well as to analyse the determinants of PHLs in the cereal and legume value chains. The study employed a cross-sectional survey design and used purposive sampling to come up with 72 respondents. Descriptive statistics of means percentages and frequencies were used to analyse the data in the study as well as multiple regression. Survey results show that males (63.9%) dominated the respondents as well as those with primary/secondary education (54.2% of the respondents). The majority (62.5%) of the respondents received post-harvest management from the extension. The average age for the respondents in the study was 34.57 whereas the average farm size was 5.3 acres. The average distance of the farm from the homestead of the respondents is 2.14km. The average distance of the market from home is 6.82km whilst the minimum distance is 0.5km. Most of the respondents (22.2% in the high loss category) indicated they had the highest losses in maize production during milling whereas the majority (18.1% in the high loss category) in legume production indicated that they had high losses during storage. From the analysis on maize PHL, distance from field to homestead (p=0.023) and distance from homestead to the market (p=0.042), average household income (p=0.062) and farm size were statistically significant at 5% and 10% significant level. Under analysis on legumes, the distance of the homestead from the field (p=0.025) and distance to the market from the homestead (p=0.050 have positive co-efficiencies which are statistically significant at a 5% significance level. Average income, years of experience and farm size are significant at 5% level and 10 % levels and have negative co-efficiencies indicating that their increase reduces the PHLs. It is recommended that there be diffusion through the extension of storage technologies amongst farmers such as silos and hematic bags to reduce PHLs as well as to increase knowledge and experience through experience sharing amongst farmers themselves. It was recommended that GMB and private offtakes have their buying points closed in communities to avoid losses associated with the transport of harvest.

Keywords *cereals, , legumes, post-harvest loses, storage.*

LIST OF ACRONYMS AND ABBREVIATIONS

APHLIS	Africa Post-Harvest Loss System
FAO	Food Agriculture Organisation
GDP	Gross Domestic Product
OLS	Ordinary Least Squares
PLHs	Post-Harvest Losses
SSA	Sub-Saharan Africa
WHO	World Health Organisation

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CHAPTER 1

INTRODUCTION

1.1 Background of the study

Agriculture is the backbone of most developing economies contributing a huge chunk to the economy in terms of foreign currency earning, contribution to GDP as well lessening the country's employment burden. Agriculture employs between 60-70 percent of the population and supplies 60 percent of raw materials as well as 40 percent of total export earnings (Government of Zimbabwe, 2012). The diverse agroecological conditions in the country enable the country to produce diverse crops and undertake other livestock and more specialised forms of agriculture activities. Legumes and cereals are important amongst the food crops grown with the majority of farmers favouring these due to their adaptable nature and ease of production under both dryland and irrigation setups.

Food security issues however remain chief amongst the topical problems in the country as well as in the continent of Africa. Hunger remains a topical issue as well with the majority of the inhabitants of Sub-Saharan Africa (SSA) facing the plight of hunger. Crop losses remain significant even during good seasons with bumper harvests. More worrying is the fact that amid these losses, about 374 million people in the region face severe food insecurity (FAO et. al, 2018). The losses according to FAO (2020) emanate to around one-third of the total yields produced. Post-harvest losses experienced in these developing countries affect the focus on having a structurally transformed African agriculture system. Post-harvest losses start at the beginning of harvest in the field and continue through the threshing and processing stages, as well as during storage, marketing, and food preparation by the final consumer along the supply value chain.

There is renewed international attention to reducing postharvest losses following the African Union member states and UN pledging to reduce the losses by 50% by 2050 and 2030 respectively. Food losses occur in terms of quality and quantity although the majority of research mainly focuses on quantification of the losses. In Zimbabwe, the lack of adequate technologies for sustainable post-harvest storage leads to significant losses in both quantity and quality for many legumes and cereals. However, the emphasis tends to be primarily on the quantity aspect rather than addressing the quality. Nutritional loses as well as lose of taste of the food is not significantly recognised by those in the rural local context. In SSA, the physical loss of food is approximately estimated at 37% or 120– 170 kg per year per capita (FAO, 2019). The World Bank et al. (2011) estimate the value of postharvest loss per year in SSA for all grains to be about $4 billion, which is more than the value of food aid received in SSA over the last decade. The volume and value of these postharvest loss estimates are alarming highlighting the urgency to better understand and reduce postharvest food losses.

1.2 Problem statement

Post-harvest losses remain a menace in agriculture production, especially in legumes and cereals leading to substantial losses in grain which has a great effect on the food security of the majority of those who live in resettlement and communal areas of Zimbabwe. Post-harvest losses (PHLs) stemming from inadequate harvesting and storage practices significantly diminish both the quality and quantity of cereals and legumes, leading to spoilage, breakage, and a substantial decrease in market value. In Zimbabwe, these losses are notably high; for instance, maize experiences a 16.5% dry weight loss nationally, with regional variations such as 16.6% in Mashonaland Central and 17.4% in Mashonaland West (Nyamangara et al., 2019). Such losses not only reduce farmers' revenues but also impede the sustainability and profitability of their enterprises. Consequently, many smallholders' farmers struggle to maintain viable legume and cereal operations, hindering their growth and contribution to the country's food and nutrition security. Quantitative losses are also encountered in the country due to lack of adequate transporting and storage technologies leading to reduced grain and legumes for consumption in the market. This contributes to reduced access to food, leading to food insecurity in the country (Nyamangara et al., 2019).

The majority of people do not have on-farm mechanisms to quantify the PHLs and this increases negligence to the importance of these losses as they reduce significantly the total yield and output of the legumes and cereals. Furthermore, many farmers are constrained by a subsistence approach, which prevents them from accurately assessing their profitability and analyzing the extent of their losses due to declines in the quality and quantity of their produce.

1.3 Objectives

1.3.1 Main objective

The study focuses on the determinants and the levels of post-harvest in Zimbabwe.

1.3.2 Specific objectives

- To determine the levels of post-harvest losses in legume and cereal production in Mazowe
- To determine whether post-harvest losses significantly vary along the value chain.
- To analyse the determinants of PHLs in legume and cereal production in Mazowe District
- To determine the strategies employed by cereal and legume farmers in Mazowe District in mitigating against post-harvest losses.

1.4 Research questions

- What are the levels of PHLs in legume and cereal production in Mazowe District?
- How do post-harvest losses vary significantly along the value chain?
- What are the factors affecting PHLs in legume and cereal production in Mazowe District?
- What are the strategies employed by cereal and legume farmers in Mazowe District in mitigating against post-harvest losses.

1.5 Justification

The research on post-harvest losses in legumes and cereals in Zimbabwe is essential for addressing a critical agricultural challenge. First, quantifying post-harvest losses provides a clear picture of the scale of the issue, which is essential for developing targeted interventions. This research will establish baseline data that can inform policy and practice. Additionally, by analysing the factors contributing to post-harvest losses, the study will uncover critical areas for intervention, helping stakeholders implement effective strategies to mitigate these losses. Exploring innovative solutions and best practices for reducing post-harvest losses will contribute to sustainable agricultural practices that ensure food security and enhance livelihoods.

The benefits of this research extend to various stakeholders. For farmers, understanding and addressing post-harvest losses can lead to increased profitability and enhanced knowledge about better storage and handling practices, empowering them to make informed decisions. The Ministry of Agriculture can utilize the findings to guide policy development aimed at reducing post-harvest losses, ultimately strengthening national food security and assisting in prioritizing resources where they are most needed. Non-governmental organizations (NGOs) will benefit by tailoring their programs to address specific post-harvest challenges identified in the study, as well as using the research framework to assess the effectiveness of ongoing initiatives.

The Grain Marketing Board will gain insights that enable them to optimize grain storage and marketing strategies, reducing waste and improving food supply chains, which in turn enhances consumer confidence in the quality of grains available in the market. Food processing companies will also benefit from this research by gaining a better understanding of post-harvest losses and their impacts on raw material quality, allowing them to improve their processing methods, reduce waste, and enhance product quality. For researchers and academics, this study will contribute to the existing body of knowledge on post-harvest management and may foster interdisciplinary collaboration among agricultural scientists, economists, and environmentalists.

Lastly, consumers will experience improved food security as reducing post-harvest losses increases the overall availability of food, while enhanced storage and processing practices ensure higher quality products reach the market, ultimately improving public health outcomes. By engaging various stakeholders and providing actionable insights, the study will contribute to improved agricultural practices, enhanced food security, and sustainable development in the region. Scope and limitations of the study

The study will focus on post-harvest losses (PHLs) in legumes and cereals within Zimbabwe, specifically examining the levels, determinants, and prevention strategies currently in place to curb these losses. Given that the area of PHLs is broad, the research will primarily concentrate on these key aspects while also addressing the marketing and economic implications of post-harvest losses. The research will target key stakeholders, including farmers, NGOs, the Ministry of Agriculture, the Grain Marketing Board, food processing companies, and consumers, to gather diverse perspectives on post-harvest management practices. While the entire country engages in the production of cereals and legumes, logistical and time constraints necessitate a focused approach; therefore, the study will concentrate specifically on the Bindura district. This will allow for a more manageable and in-depth analysis of post-harvest losses within a defined geographical area. The study will assess losses occurring at various stages of the value chain, including harvesting, storage, transportation, and processing, utilizing both quantitative methods to measure the extent of losses and qualitative methods, such as interviews and focus group discussions, to identify the underlying determinants and gather insights on prevention strategies.

1.6 Limitations of the Study

Several limitations may affect the study's findings. First, the availability and accuracy of data on post-harvest losses can be challenging, as many farmers may not accurately report losses due to various factors, including lack of awareness or reluctance to disclose information. Additionally, the study may face logistical challenges in accessing certain areas within Bindura, which could limit the representativeness of the sample. Another limitation is the potential for bias in qualitative data collection, as stakeholder perspectives may be influenced by personal experiences and vested interests. Furthermore, the rapidly changing agricultural landscape in Zimbabwe, influenced by factors such as climate change and economic conditions, may affect the relevance of the findings over time. While the study aims to provide a comprehensive analysis of post-harvest losses, it will not cover all possible factors influencing these losses due to the complexity of agricultural systems and varying local practices.

1.7 Outline of Thesis

Chapter one of the thesis contains the introduction of the thesis which is the background of the study and the statement of the problem. It also contains the thesis aim and specific objectives as well as the research questions. The chapter also has the delimitation of the significance of the study and the conclusion of the study. Chapter two of this thesis contains the literature review of the study which includes the conceptual and the empirical framework. Chapter three of the study contains the research methodology which includes the area of the study, the research methodology, the sampling and data collection procedure together with the research analysis framework. It also contains the ethical considerations of the study. Chapter 4 contains the presentation and discussion of results on the levels of post-harvest losses. Chapter five contains the results on determinants of post-harvest losses as well as the strategies employed to reduce post-harvest losses in cereals and legumes. Chapter six contains the summary of results, the conclusions and recommendations of the study which is the last chapter of the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Postharvest loses are a major concern to food production as well as food security. The losses incurred also have a similar effect on the economic welfare and the livelihoods of the rural communities of Zimbabwe. Farmers and food markets are worried about these losses that occur throughout the post-harvest chain, from the harvesting phase to processing, transportation, selling, and consumption. (Grolleaud, 2002). A lot of food wastage and spoilage occur along this chain which have nutritional and economic implications not only to the rural communities but have a compounding effect on the globe as a whole. Strategies to cut down postharvest losses are critical at this stage to improve the efficiency of the agriculture production system (Stathers et al., 2018).

Postharvest losses can be classified as physical, which involves volume shrinkage or deterioration in quality; nutritional, such as grain contaminated with aflatoxin and molds; or economic, which includes a decrease in unit sale value and reduced access to markets for the affected grain or cereal. These postharvest losses are caused by physical and mechanical abrasion, environmental dynamics such as temperature, pests and animals, pathogens through the formation of moulds and aflatoxin as well as humans through theft. These losses occur at four stages along the postharvest chain, that is in the farm, during transportation, during processing in the homestead and then in the storage facility. Therefore, there is a need to harness technologies that curtail these losses to increase productivity of the sector while also preserving the nutritional value of every harvested cereal and legume.

2.2 Cereal and legume production in Zimbabwe

2.2.1 Cereals

Cereals are a staple in the diets of many people in Africa, with a significant portion of these crops originating from and being primarily cultivated on the continent. The cereal maize in a key crop in the diet as it is a staple in Zimbabwe. It is also the major grown cereal amongst other cereals like sorghum and millet. Maize accounts for over 70% of agriculture land utilisation with other cereals occupying a minute fraction of the land. Maize is grown in diverse agroecological zones in the country with supplementary water needed in regions 4 and 5. Cereals, particularly maize, are the primary source of calories for rural households in Zimbabwe. Most households rely on maize for their food security and livelihoods, as it serves both as a vital food crop and an important source of income.

The five-year average yield for Zimbabwe is 1 tonne per hectare, with concerns that this may decline further due to climate change and variability (FAO, 2020). Meanwhile, the output of sorghum and millet is increasing, driven by institutional support and the effects of climate change, as many farmers are choosing to cultivate these drought-tolerant small cereals.

Legumes belong to the family Leguminosae, which produces seeds within pods and includes a total of 18,000 species, with common varieties such as peas, broad beans, lentils, soybeans, groundnuts, and mung beans (Foti & Mwanza, 2020). In sub-Saharan Africa, cowpeas, soybeans, and common beans are particularly important for rural communities, playing a crucial role in enhancing food security and meeting dietary needs (Onyango, 2017). In Zimbabwe, legumes are primarily grown on a small scale in rural areas, mainly for household consumption, and serve as an affordable meat substitute. Post-Harvest Losses of cereal and legumes in Zimbabwe

2.2.2 Post- Harvest Losses

Postharvest loss in food crops is an enormous challenge in the attainment of food security and sustainable development goals such as the eradication of hunger. In many cases, the emphasis is placed on achieving high yields, while insufficient attention is given to the total yield after all processes, including transportation, have been completed. Postharvest losses occur between the harvesting period and the consumption of cereals. These losses include on-farm reductions during threshing, winnowing, and drying (Chingarande & Kandiwa, 2015). Additionally, losses can occur along the product chain during transportation, storage, and processing. According to APHLIS, (2019) a total estimation of 371, 118 tonnes were lost in 2019 using postharvest losses as shown in Table 1. A total of 9433 tonnes and 5488 tonnes were recorded as losses for sorghum and millet respectively. This results in a total economic loss for cereals in Zimbabwe amounting to USD 105,412,602.85. According to the USDA's 2018 nutrient loss assessment, postharvest losses in 2019 were significant, with losses of 18.9%, 12.6%, and 9.6% reported (APHLIS, 2019).

Table 2.2.2-1 Dry weight postharvest losses for Zimbabwe by Province for the year 2019

Proince	Maize (tonnes)	Sorghum (tonnes)	Millet (tonnes)
Manicaland	49,916.00	1,999.00	1,898.00
Mashonaland Central	80,710.00	1,563.00	73.00
Mashonaland East	52,755.00	420.00	193.00
Mashonaland West	95,516.00	313.00	20.00
Masvingo	17,931.00	2,183.00	1,260.00
Matabeleland North	8,695.00	716.00	1,000.00
Matabeleland South	11,601.00	799.00	663.00
Midlands	53,994.00	1,440.00	381.00
TOTAL	**371,118.00**	**9,433.00**	**5,488.00**

Source: www.APHLIS.net 2020

2.2.3 Legumes

Legumes are also susceptible to postharvest losses. If they are not properly dried, they can develop molds or become damaged in the field, as they are typically confined within pods. If legumes for example beans are harvested before their required moisture has set which is usually 13-15%, they form moulds inside their pods, and this leads to the deterioration of the seed quality which in the end cannot be consumed or sold. Also, if the legumes like beans are left in the field for long after harvesting and if they are over-dry, they become more prone to pests and splatter from their pods as their natural method of seed dispersal. This leads to losses since the seeds can then be picked by birds and rodents.

2.3 Main elements of the postharvest system

a) Harvesting

Harvesting is mainly determined by the degree of maturity of the cereals or the pulses. A distinction should be made between the maturity of stalks, seeds, and pods for all the successive operations like storage and processing to take place.

b) Pre-harvesting drying

Effective pre-harvest field drying ensures good preservation but can lead to many losses due to attack by pests like birds, rodents and insects like LGB. Molds can develop on seeds if there are moisture surges in the field, leading to significant postharvest losses for legumes. Proper drying and storage are essential to prevent this issue.

c) Postharvest drying

Weather and atmospheric conditions affect greatly the length of the drying time needed for the ears and the seeds. Structures in which grain is dried such as unroofed floors and cribs offer an opportunity for pests and livestock to attack the harvest contributing to losses. The grain can also be stained by waste from pests like rodents reducing the quality of the grain. If grain is left for longer periods to dry, excessive drying leads to weight loss and further loss of nutritional value as well as income.

d) Threshing

Drying plays a major role in determining the effectiveness of threshing and its effect on postharvest losses. If threshing is done before proper drying of the grain or the ears, then some of the seeds or grain will be left on the stalks. Threshing over dried grain leads to cracking grain especially when mechanical means are used on the cereals or the legumes. Threshing when the grain is well above its required moisture content, storage and seed or grain quality will be affected by mould formation.

e) Storage

Storage is paramount for postharvest loss prevention. Several methods are employed for different crops since they are harvested at different intervals as well. Structures generally need to be dry and well-ventilated as well as cool to maintain the quality of grain since improper storage is a huge contributor to post-harvest losses. Preservation of the grain quality also translates to preservation of nutrients; some grains lose their nutrient quantity if stored under the sun for longer periods for example orange maize which can lose its vitamin C concentration.

2.4 Major causes of post-harvest losses of cereals and legumes in Zimbabwe

2.4.1 Pests

Pests are a major contributor to the postharvest losses experienced in rural communities and are further exacerbated by a lack of pesticides and effective grain storage and postharvest management technologies. The grain weevil is a primary pest of stored cereals as well as legumes. They establish themselves in the grain and legumes as long as the grains are not exceptionally dry. The Large Grain Borer is a highly destructive primary pest for cereals in particular maize especially when it is on the cob (Kiaya, 2014). The issue with these two is that they can initiate damage well before harvest has commenced, meaning that they can even start contributing to the loss’s way before the finalisation of processing. These pests leave their excretion and deform the grain, sometimes living grain in powdery form.

2.4.2 Moisture

Moisture plays a critical role in postharvest loses, if grain and seeds are over-dried, they splatter and crack during their processing as well as lose their nutrient content. This moisture can also create cracks in the seeds, which provide entry points for pests. These pests can then burrow into the seeds, further compromising grain quality. Additionally, predators and theft become significant concerns when the drying process exceeds its normal duration, particularly after harvesting. This can lead to further losses in both quantity and quality of the produce. (FAO, 2016). It also leads to many wastages which occur during processing as some grains might fail to detach from the stalks.

2.4.3 Transportations

Transportation is critical in postharvest losses. Grain can detach during transportation and pod splattering is also common if transportation is not suited to transport the cereal or the legumes (Stathers et al., 2018). Some of the grain might fall on the ground and some of the seeds or grain might crack which might harbour pests. The majority of the carts used to ferry grain in rural areas lack canopies and if rain falls the grain being transported is affected greatly. Poor infrastructure, such as poor roads and improper transportation methods, significantly impacts the movement of grain. These issues can lead to increased postharvest losses due to delays, physical damage, and spoilage during transit. (Grolleaud, 2002). Small cereals need to be transported under cover, as external factors like wind and birds can cause significant wastage. Additionally, falling during transport can further contribute to losses, compromising the quality and quantity of the grains.

2.4.4 Management

General management is critical during all the critical stages of the postharvest period that is during shelling, plucking winnowing, storage, packaging and transportation. Failure to take great management during any of these stages leads to massive postharvest losses. Reckless transportation leads to spillages of grain, and reckless storage in damp, sun-exposed places leads to mould formation of grain deteriorating its quality as well as its weight and nutritional value (Kiaya, 2014). Grain is also prone to theft if left in unsecured storage places which is another chief contributor to postharvest losses.

2.4.5 Environmental factors

Climatic conditions which include rainfall, temperature, wind humidity and altitude affect postharvest management of cereals and legumes (Grolleaud, 2002).

a) Temperature affects the drying of grain. Too much temperature causes splattering of pods in legumes as well as easy cracking of cereals. Temperature also affects the development of crops if it is mismatched with the available rainfall, this contributes to rampant incidents of pests as well as poor grain development which is very susceptible to pest attack. Grain borers favour seeds with weak developed outer coating since it's easy to get through.
b) There is a movement in the continuum between dry grain and the surroundings in terms of the movement of humidity. Grain tends to absorb humidity from the surroundings (Atanda et al., 2011). There is a need to ensure that storage is free from any moisture since it leads to chemical reactions which lead to high microbiology activity degrading the quality of grain through mould formation.
c) Wind contributes immensely to postharvest losses. The wind is beneficial during winnowing but is dangerous when the grain is lighter and when it has over-dried since it can carry grain away from its intended place. Even during transportation, wind can carry away grain if it is improperly covered.

2.5 Strategies to minimise postharvest losses

Many strategies can employ to minimize postharvest losses. The various strategies can be employed to the stage in the postharvest period up to the final consumer.

Stage	**Description and Strategies**
Harvesting	Proper Timing: In rural Zimbabwe, cereals and legumes are harvested during a single season. Grains should be harvested at a moisture content of 20-30% (Chingarande & Kandiwa, 2015). Harvesting Techniques: Use appropriate methods to reduce damage during harvesting. Avoid premature harvesting due to food shortages, which can lead to nutritional and economic losses (Kiaya, 2014).

Drying	Farmers often rely on sunshine and atmospheric air for drying. Humid conditions and rainfall can cause significant losses (Kiaya, 2014). Optimal Moisture Content: Aim for a moisture level of 13-15% to prevent mold formation. Over-drying can lead to weight and nutrition losses, and economic disadvantages.
Threshing and Shelling	Timely Processing: Delays in threshing, especially for sorghum and millet, can lead to significant losses. Use of Mechanical Tools: Employ small hand shellers to reduce mechanical damage and improve efficiency (Mvumi et al., 2017).
Winnowing and cleaning	This activity is done before storage or marketing. The process is done manually with the aid of atmospheric air. This method is generally ineffective as some grain gets blown away by wind during the process. It is also a technology that leaves the grain with some chuff which creates a good breeding ground for pests (Shee et al., 2019). Commercial Equipment: Utilize commercial fans for winnowing to enhance efficiency and reduce losses.
Storage	Poor storage conditions increase postharvest losses. This includes also a lack of storage capacity. Storage spaces need to be constructed in such a way that they are dry,

	and well-ventilated allowing drying as well as protection from rain and other external environmental factors as well as rodents and theft (Kiaya, 2014). Improved Conditions: Ensure storage facilities are dry, well-ventilated, and protected from environmental factors and pests (Kiaya, 2014). Innovative Storage Solutions: Use hermetic bags and metal silos to effectively prevent pest infestations. Enhance Access: Improve access to markets to minimize the time grains spend in storage, thereby reducing potential losses.
Transportation	Safe Methods: Implement safe transportation methods to minimize physical damage and exposure to external factors during transit. Advocacy for Better Roads: Improve roads and transportation systems to facilitate efficient movement of goods and reduce postharvest losses.
Packaging	Suitable Materials: Use appropriate packaging materials to protect grains from environmental hazards and pests.

2.6 Theoretical Framework

In this article, the resilience theory has been adopted to explain how the various smallholder farmers can benefit in terms of nutrition as well as how they can be profitable in fish farming considering the various issues surrounding the enterprise. The theory is fundamental as it draws on the remembrance of ways and strategies which had been used over time to try and cope with challenges affecting the livelihoods of smallholder farmers in high-risk areas. Resilience theory plays a major role in achieving sustainable legume and cereal farming as social and ecological capacities given the failure of other rural economic livelihoods such as livestock rearing and agriculture (Maleksaeidi & Karami 2013). Given the effects emanating from climate change, the theory strengthened cereal and legume farmers in Mazowe district to resist any shocks and stresses such as Elnino-induced droughts which may disrupt their livelihoods; hence, fish farming can generate employment and improve food security among households.

Many authors provide different conflicting versions of the evolution of resilience theory. Van Brenda (2001) claims that resilience theory has been evolving over the past 70–80 years and subjecting itself to renaissance over the previous two or three decades. These authors regard the theory as a concept that changes people's focus from the breakdown and disorder emanating from exposures to stressful environments, to individual characteristics and social processes associated with either normal or unexpected psycho-social development (Greene et al. 2003; Van Brenda 2001). The European Union Factsheets (2015) describes resilience as the ability of an individual, a household, a community, a country or a region to withstand, cope, adapt, and quickly recover from stresses and shocks such as violence, conflict, drought and other natural disasters without compromising long term development. Crawford et al. (2005) add that resilience involves the search for knowledge about the processes which can contribute to positive adaptation and development in the context of adversity and disadvantage. Brand and Jax (2007) explain resilience as a concept embedded in sustainability that is applied in various disciplines to understand socio-ecological systems. Often resilience theory is used to understand how multi-faceted systems change and how they withstand any disturbances that may occur (Janssen et al. 2006). From the aforementioned assertions, Walker et al. (2002) define resilience as the social-ecological system that has the potential to absorb disruptions and restructure itself while experiencing a change to maintain its function, identity, feedback and structure. Therefore, resilience in social-ecological systems involves several techniques that are used to adapt to change, stressors and sudden shocks (Adger et al. 2005).

2.7 Conceptual Framework of the study

The conceptual framework for this study is grounded in the Sustainable Livelihoods Framework (SLF), which provides a comprehensive approach to understanding the multifaceted nature of livelihoods, particularly in agricultural contexts. The SLF emphasizes the interplay between various forms of capital—natural, human, social, financial, and physical—and how these capitals influence the sustainability and resilience of livelihoods, especially in relation to post-harvest losses (PHLs) in legume and cereal production (Department for International Development (DFID), 2000). The SLF posits that livelihoods are shaped by the interaction of five key types of capital:

Natural Capital: This includes the natural resources and environmental conditions that farmers depend on for their agricultural activities. In Mazowe District, the quality of soil, availability of water, and biodiversity are critical factors that influence crop yields and vulnerability to losses (Chitongo & Magaya, 2013).

Human Capital: Referring to the skills, knowledge, and health of individuals, human capital plays a vital role in determining farmers' ability to adopt effective post-harvest management practices. Training and education can enhance farmers' understanding of best practices, thereby reducing losses (Alinovi, Hemrich, & Russo, 2010).

Social Capital: This encompasses the relationships and networks that facilitate cooperation and support among individuals and communities. In the context of Mazowe, social capital can influence the sharing of knowledge and resources, which is essential for implementing strategies to mitigate PHLs (Chitongo & Magaya, 2013).

Financial Capital: Access to financial resources, such as credit and savings, significantly affects farmers' ability to invest in necessary technologies and infrastructure. Financial constraints can limit the adoption of improved storage and transportation methods, which are crucial for minimizing post-harvest losses (Alinovi et al., 2010).

Physical Capital: This includes the tools, equipment, and infrastructure that support agricultural production and post-harvest handling. The availability and condition of storage facilities, transportation systems, and processing technologies directly impact the efficiency of post-harvest operations (DFID, 2000).

The study aims to achieve the following objectives, each linked to the components of the SLF:

1) **Determine the Levels of Post-Harvest Losses:** This objective seeks to quantify the extent of losses in legume and cereal production in Mazowe, providing insights into the natural and financial capital lost due to inefficiencies in the post-harvest process.
2) **Assess Variability Along the Value Chain:** By analyzing how PHLs vary at different stages of the value chain, this objective will highlight the roles of social and physical capital in influencing losses and identify areas for targeted interventions.
3) **Analyse Determinants of PHLs:** This objective will examine various factors influencing PHLs, linking them to the natural and human capital available to farmers. Understanding these determinants helps to identify vulnerabilities in farmers' livelihoods.
4) **Identify Mitigation Strategies:** This objective focuses on the strategies employed by farmers to reduce PHLs, emphasizing the importance of human and social capital in fostering resilience and effective management practices.

The integration of the Sustainable Livelihoods Framework into this study provides a robust foundation for analysing post-harvest losses in Mazowe District. By examining the interplay between different forms of capital and their influence on PHLs, the study aims to develop a comprehensive understanding of the challenges faced by farmers and the strategies they employ to enhance their livelihoods. This framework will guide the analysis and contribute to identifying sustainable solutions that not only reduce post-harvest losses but also support the overall resilience and sustainability of agricultural practices in the region.

2.8 Chapter Summary

This chapter focused on the literature review of the study. It opened with the conceptualisation of the key terms which included post-harvest losses, cereals and legumes. It also took a deep dive into the literature on the objective on the levels of post-harvest losses, the determinants of post-harvest losses, and the strategies to mitigate the post-harvest losses. The chapter also contains the conceptual framework where it adopts the Sustainable Livelihoods Framework which is linked to the objectives of the study.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The previous section looked at the review of the literature. This chapter looks at the methodology of the study which opens with the description of the study, the research design and the sampling procedure. This section also looks at the data collection and analysis procedure as well as the ethical considerations taken into this study.

3.2 Description of the study site

The research was carried out in Mazowe District which is located in Mashonaland Central Province. This is one of the areas which houses the prime agricultural lands of Zimbabwe in the demarcated agroecological region 2. Mazowe is known for its richness in agriculture and mining housing the country's largest citrus estates as well as flourishing maize and soya beans farmers. This region is located in the middle of the north of the country. The rainfall ranges from 750 to 1,000 mm/year. It is fairly reliable, falling from November to March/April. Because of the reliable rainfall and generally good soils, NR II is suitable for intensive cropping and livestock production. It accounts for 75-80 percent of the area planted for crops in Zimbabwe.

The cropping systems are based on flue-cured tobacco, maize, cotton, wheat, soybeans, sorghum, groundnuts, seed maize and burley tobacco grown under dryland production as well as with supplementary irrigation in the wet months. Irrigated crops include wheat and barley grown in the colder and drier months (May-September). NR II is suitable for intensive livestock production based on pastures and pen-fattening utilizing crop residues and grain. The main livestock production systems include beef, dairy, pig and poultry. Before 2000, the region was dominated by the large-scale farming subsector characterized by highly mechanized farms of 1 000-2 000 ha under freehold title and owner operated. Following the agrarian and land reform programmes initiated in 1999/2000, a large proportion of the farms were subdivided into smaller units and allocated to new farmers under the A1 and A2 small-scale farming systems.

3.3 Research design

The research adopted a descriptive survey design, incorporating both qualitative and quantitative data. A descriptive survey design involves the collection of data at a single point in time from a sample that is representative of the population under study. This design is particularly suitable for this study as it allows for the simultaneous analysis of various variables related to post-harvest losses in legumes and cereals among smallholder farmers in Mazowe District. The design's strength lies in its efficiency and cost-effectiveness, enabling the researcher to obtain a snapshot of the prevailing conditions, practices, and challenges within the farming communities. According to Chali, Eshete, and Debela (2022)**,** cross-sectional surveys are ideal for identifying relationships and drawing inferences about population characteristics, which is critical when addressing agricultural and socio-economic issues.

3.4 Sampling procedure

A purposive sampling procedure was used to select respondents in the study. Purposive sampling was employed in the study to select the respondents in the study. Taherdoost, (2021), highlights that purposive sampling, also known as judgmental, selective or subjective sampling, reflects a group of sampling techniques that rely on the judgement of the researcher when it comes to selecting the units (e.g. people, case/organisations, events, pieces of data). The major advantage of purposive sampling for the study at hand is that it provides the researcher with the justification to make generalisations from the sample under study. In addition, it also provides a wide range of non-probability sampling techniques for the researcher to draw on. For example, critical case sampling may be used to investigate whether a phenomenon is worth investigating further, before adopting an expert sampling approach to examine specific issues further (Sharma, 2017).

Mazowe District was selected through simple random sampling since it has a lot of cereal and legume farmers who can provide valid and relevant information for the study. Ward 2 was also selected using purposive sampling. In conjunction with Agriculture extension personnel in the district, a list of communal cereal and legume farmers was produced with a total of 219 households which gave us a total of 71 respondents each from one household. The respondents were also selected through purposive sampling in Mazowe District; the farmers were selected on the basis that they could provide the information relevant for the study.

To determine the sample size Slovin's formula was used

Sample size $n = N/(1 + Ne^2)$

Where:

n = sample size (72)

N =Population size (219 households)

e = error margin / margin of error(0.10)

3.5 Data collection procedure

Data was collected using several data collection methods which include survey questionnaires, key informant interviews and focus group interviews. A pilot survey was done before the actual data collection to ascertain the feasibility of the questionnaire to non-survey respondents. Mock interviews were also done by the researcher to ascertain if the interview questions would produce the required information for the research questions of the study.

3.5.1 Questionnaire

The main method of data collection in the study was the survey questionnaire which is a research instrument consisting of a series of questions or other types of prompts that aim to collect information from the respondent (Nassaji, 2015). The questionnaire used for this study contained both closed-ended and open-ended questions to be able to collect a lot of relevant information from the respondents. The questionnaire contained both qualitative and quantitative probing questions that were able to collect data on those two aspects required for the research (Thomas, 2022). A total of 72 questionnaires were constructed by the researcher on the respondents sampled for the study.

3.5.2 Key Informant Interviews

Key informant interviews were also used in the study. These are qualitative in-depth interviews with people who know what is going on in the community. The purpose of key informant interviews is to collect information from a wide range of people including community leaders, professionals, or residents who have first-hand knowledge about the community. The advantage of KIIs is that they allow one to get technical and some of the important details of the area and phenomenon from a technical point of view which can then be used to verify the information coming from the other respondents in the study. 5 key informant interviews will be carried out at the District Development Offices with the District Development Administrator and one respondent from the Metrological office as well as with the chief for the area together with 2 extension officers to establish the way of life as well as in-depth knowledge on drought in the area. The responses from the key informant interviews were used in triangulation in the study.

3.6 Data analysis procedure

The research involved analysis of both qualitative and quantitative data, of which qualitative data was analysed using descriptive statistics such as percentiles and sum whereas qualitative data was analysed using means, standard deviation as well as independent t-tests for statistical significance (Baždarić, et al. 2021). OLS Regression was used to analyse the factors that affect post-harvest losses.

Table 3.6.1 below shows the objective, and the analysis tool used to measure the outputs of the objective.

Table 3.6.1 Analysis method for objectives

Research Objective	**Data Analysis Method Used**	**Explanation**
To determine the levels of post-harvest losses in legume and cereal production in Mazowe	Descriptive Statistics	Used to summarize and present data on the extent and frequency of post-harvest losses among farmers.
To determine whether post-harvest losses significantly vary along the value chain	ANOVA (Analysis of Variance)	Applied to test for statistically significant differences in loss levels across different value chain stages.
To analyse the determinants of post-harvest losses in legume and cereal production in Mazowe District	Regression Analysis	Used to identify and assess the relationship between various factors (independent variables) and post-harvest losses (dependent variable).

To determine the strategies employed by cereal and legume farmers in Mazowe District in mitigating against post-harvest losses	Descriptive Statistics	Utilized to summarize the different mitigation strategies adopted by farmers and their frequency of use.

3.6.1 Multiple Regression Analysis (OLS)

(Alidu et al., 2016) used multiple regression to analyse the factors affecting post-harvest losses. OLS model of regression was used to analyse the data collected. Y on the model is the total amount repaid whereas (β0, β1, β2, β3… β13) are explanatory variables. (Anigbogu et al., 2014) quotes Gujarati (2008) highlighting the advantages of this model claiming that, the use of (OLS) is informed by the fact that under normality assumption for that is, the OLS estimator is normally distributed and is said to be the best, unbiased linear estimator.

For this research, the model will be specified as below (Sarstedt, et al. 2019).

Y = β0 + β1AGE + β2SEX + β3EDUCATION + β4FARMSIZE + β5HHSIZE + β6YEARSOFEXPERIENCE + β7AVERAGEINCOME + β8DISTFIELDSTORAGE+ β9DISTSTORAGEMARKET + β10EXTENSION + β11MEMBERSHIPOFORG + e ………………………………………..

3.6.2 Description of Dependent and Independent Variables

Table 3.6.2 shows the variables included in the regression equation and whether they are continuous or categorical. The table also shows the hypothesised effect on PHLs.

Table 3.6.2 Explanation of Variables in the Study

Variable	Continuous/categorical	Effect on PHL
Dependent		
PHL (%) for maize and beans	Continuous	
Independent		
Age	continuous	+\-
Sex	Categorical (1 for male and 0 for female dummy)	+
Education	Continuous (number of years of education)	-

Farm size	Continuous (acres)	+\-
Household size	Continuous (number of members)	-
Year of Experience	Continuous	-
Average Income	Continuous (US$)	-
Distance to storage	Continuous (km)	+
Distance to market	Continuous (km)	+
Contact with Extension	Categorical (1 for Yes and 0 for No dummy)	-
Membership of Organisation	Categorical (1 for Yes and 0 for No dummy)	-

Post-harvest loss (PHL) is the dependent variable in the study. It is a continuous variable and is measured in the average percentage lost during the chain after harvesting to the final consumer. The respondents were asked to pick out of 100 grains their perceived loss at each of the post-harvest chain activities. These were added together to come up with the % loss.

Age is a continuous variable in this study depicting the number of years from birth. This variable is hypothesised to have both a positive and negative effect on post-harvest losses. Young people have the energy and are also up to date with technology on the prevention of post-harvest losses. On the other hand, the elderly have very effective techniques to minimise post-harvest losses through the experience they would have earned.

Sex is a categorical variable in this study which is depicted by male or female. Female is the dummy variable in the study whilst male is the reference category. It is hypothesised in the study to have both a negative and positive effect on the PHL.

Education is a continuous variable in the study which depicts the number of complete years in formal education setup. It is hypothesised to have a decreasing effect on PHL. The higher the number of years in formal education, the more knowledge and information one acquires as well as the more ability one acquires to transfer the knowledge into practice. Education is also linked with an adoption rate of PHL-reducing technologies.

Farm size is also a continuous variable in the study depicting the size of the farm. It is measured in the study in acres since this study deals with smallholder farmers. Farm size is hypothesised to negatively impact on post-harvest losses. Those with bigger farm sizes can use mechanical technologies to harvest their crop as well as transport their crops thereby leading to reduced PHLs compared to those with smaller land sizes.

Household size is a continuous variable in the study depicting the number of people in the household. The larger the household size, the less the PHL since there is more labour force to assist with transportation and sorting of the grain. It also speaks to the speed at which harvesting occurs as well as transportation and sorting.

Years of experience is a continuous variable in the study depicting the years of farming experience for the respondent. The higher the years of experience the lesser the PHL in legumes. Those with higher experience know techniques that can store their grain even after harvesting and during sorting and transportation.

Average household income is a continuous variable for the average household income. The higher the income the more investment into transportation and effective storage and sorting facilities for legumes and maize hence less post-harvest losses.

Distance between field and storage is a continuous variable in the study which depicts the distance from the storage facility which usually is the homestead to the market. The longer the distance the more the PHLs are what is hypothesised in the study. The more the distance the more vulnerable grain is to quality and quantity losses also depending on the type of transport.

Distance between storage and marketing is also a continuous variable that affects PHLs. The more the distance the more vulnerable grain is to quality and quantity losses also depending on the type of transport. The distance is hypothesised therefore to have an increasing effect on PHL.

Contact with extension is a categorical variable which depicts if the farmer had contact with extension and was given information on post-harvest loss mitigation. It is also a dummy variable with Yes and No. Contact with extension on PHLs messaging is hypothesised to reduce PHLs since the respondent will know how to prevent PHLs.

Membership of Organisation is a categorical variable which depicts if the respondent is a member of any community organisation such as the farmers' club or any other social group. There are a lot of messages around good agriculture practices and post-harvest which are disseminated during meetings in these organisations which generally lead to change in post-harvest management.

3.7 Ethical considerations

The researcher adhered strictly to ethical research principles throughout the conduct of the study to ensure the protection and dignity of all participants. Prior to data collection, formal permission was obtained from the relevant academic institution, as well as from the local authorities and community leadership within the study area. This step was crucial in legitimizing the research process and fostering trust and cooperation from the community. Participants were thoroughly informed about the purpose, scope, and expected outcomes of the study. They were also assured of the confidentiality and anonymity of the information they provided, with a clear explanation that their responses would be used solely for academic purposes and would not be disclosed to any third party. In order to document informed consent, each respondent was asked to voluntarily sign a confidentiality indemnity form, indicating their understanding and agreement to participate in the research. This ethical approach not only upheld the integrity of the research but also ensured that the rights, privacy, and autonomy of all respondents were fully respected.

3.8 Summary

The section focused on the methodology of the study. It employed a cross-sectional survey design and used purposive sampling to select a sample size of 72 respondents from Ward 2 Mazowe. Data was mainly collected using structured questionnaires and key informant interviews. Data in the survey was analysed using descriptive statistics such as frequencies and means and also using a Likert scale for ranking. Regression was used to analyse the factors affecting harvest losses in legumes and cereals amongst the respondents.

CHAPTER 4

CHARACTERISATION OF RESPONDENTS AND THE LEVELS OF CEREAL AND LEGUME HARVEST LOSSES

Abstract

Post-harvest losses begin from the onset of harvest in the field and go on to the transformation to the threshing and processing, the storage as well as in the marketing as well as preparation of the food by the final consumer along the supply value chain. The losses according to (FAO, 2020) emanate to around one-third of the total yields produced. Post-harvest losses experienced in these developing countries affect the focus on having a structurally transformed African agriculture system. This section focuses on the characterisation of the respondents as well as the determination of the postharvest losses in the legume and cereal value chain. Data was collected using a questionnaire. Survey results show that males (63.9%) dominated the respondents, as well as those with primary/secondary education (54.2% of the respondents). Sixty-two and a half percent (62.5%) of the respondents, received post-harvest management from extension. The average age for the respondents in the study was 34.57 whereas the average farm size was 5.3 acres. The average distance of the farm from the homestead of the respondents is 2.14km. The average distance of the market from home is 6.82km whilst the minimum distance is 0.5km. The majority of the respondents (22.2% in the high loss category) indicated they had the highest losses in maize production during milling whereas the majority (18.1% in the high loss category) in legume production indicated that they had high losses during storage. From the survey results it can be recommended that farmers take great introspect into the storage stage especially in legumes since that were the majority face high losses through grain borers. There is a need to have proper storage facilities in place to avoid such losses as well as grain protectants.

Keywords: *Post-harvest Losses, storage, milling, socio-economic, distance*

4.1 Introduction

This section focuses on the presentation, discussion, and analysis of the first two objectives which are the socio-economic characteristics of respondents and the determination of the PHLs in the legume and cereal value chains. The chapter also contains the recommendations from the findings as well as the conclusion.

4.2 Descriptive Characteristics of Respondents

Table 4.2-1 below shows the descriptive characteristics of respondents in the study. The majority of the respondents according to the table were male (63.9%) whereas 36.1% were female. The majority of the respondents had attained primary/secondary education (54.2%). Only 9.7% of the respondents did not attend either informal or formal education. Education improves decision-making and assimilation of information hence better post-harvest loss management (Alidu et al., 2016). 70.8% of the respondents had a membership with an organisation in their communities and only 29.2% were not members. This finding concurs with (Shee et al., 2019) who also had the majority of respondents in community organisations. Community organisations are critical in spreading information which might help in post-harvest management (Nyamangara et al., 2019). In addition, the majority (62.5%) of the respondents in the study received post-harvest management messaging from extension whereas 37.5% of the respondents did not receive extension messaging on postharvest management.

Table 4.2-1 Descriptive characteristics of respondents

Variable		**n=72**	**%**	
sex	female	26	36.1	
	male	46	63.9	
Education	Non	7	9.7	
	Informal	16	22.2	
	Primary/Secondary	39	54.2	
	Tertiary	10	13.9	
Membership of organisation	No	21	29.2	
	Yes	51	70.8	
Extension	No	27	37.5	
	Yes	45	62.5	
	min	**max**	**mean**	**std deviation**
Age	21	65	34.57	10.545
Average Income	20	1200	199.72	189.001
Years of experience	1	15	5.31	3.079
Farm size	1	15	5.22	2.918
Distance of Field from home	.20	6	2.14	1.378
Distance of market from home	.50	25	6.82	5.463

Table 4.2-1 also shows the quantitative characteristics of the respondents. The average age in the study is 34.57 years. This shows that the respondents in the study are within the economically active age range. The average income per month for the respondents is US$199.72 and the average year of experience is 3 years. The average farm size is 5.31 acres. This concurs with the findings of (Chingarande & Kandiwa, 2015) who found the average acreage at around 5. Farm size has a huge effect on post-harvest losses with larger pieces of land allowing mechanisation which is efficient in reducing the PHLs. The average distance of the farm from the homestead of the respondents is 2.14km. The average distance of the market from home is 6.82km whilst the minimum distance is 0.5km. The longer the distance the grain has to be transported the more the losses likely to be accumulated.

4.3 Determination of harvest losses of cereals and legumes

This section looks at the harvest losses experienced by the respondents. The respondents were asked to estimate their loss at each of the post-harvest value chains. The PHLs were categorised into minimum loss, low loss, moderate loss, and high loss. Averages were also used to produce the rankings of where the greatest losses occurred along the cereal and legume value chain.

4.3.1 Percentage of post-harvest losses for cereals

Table 4.3-1 below shows the percentage of the perceived post-harvest losses by the respondents. Over 30% of the respondents reported to have lost less than 1% and 1-3% of their harvest during the harvesting period whilst 12.5% reported to have high losses of over 7% during this stage. More than 40% of the respondents indicated that they had minimum losses during the de-husking, shelling, storage, milling and selling stages. Whilst only 22.2% reported to have high losses during milling.

Table 4.3-1 Percentage Post-harvest Losses for maize

Maize PHLs	**Harvesting**	**De-husking**	**Transportation**	**Drying**	**shelling**	**Storage**	**milling**	**Selling**
Minimum Loss (Less than 1%)	33.3	41.7	15.3	37.5	38.9	43.1	41.7	41.7
Low loss (1-3%)	37.5	36.1	48.6	29.2	31.9	40.3	31.9	41.7
Moderate loss (3-7%)	16.7	16.7	25	18.1	18.1	8.3	4.2	9.7

High Loss (Over 7%)	12.5	5.6	11.1	15.3	11.1	8.3	22.2	6.9

4.3.2 Percentage of post-harvest losses for legumes

Table 4.3-2 below shows the perceived percentage losses for legumes amongst the respondents. 61.8% of the respondents indicated that they had the minimum post-harvest loss during selling. More than 40% of the respondents in the study indicated that they had a minimum loss during harvesting, de-husking, and storage. Only 19% of the respondents indicated that they had the least loss during shelling. Storage was selected by the majority of the respondents (18.1%) amongst the other activities along the value chain as one of the activities where they had high post-harvest losses. Transportation amongst the other activities was perceived as the activity with the least cause of high losses with only 2.8% of the respondents.

Table 4.3-2 Post-harvest percentage losses for Legumes

Beans PHL	**Harvesting**	**De-husking**	**Transportation**	**Drying**	**shelling**	**Storage**	**Selling**
Min Loss (Less than 1%)	47.2	44.4	50	34.7	19.4	45.8	68.1
Low loss (1-3%)	29.2	25.0	38.9	33.3	59.7	34.7	18.1
Moderate loss (3-7%)	18.1	20.8	8.3	22.2	12.5	1.4	8.3
High Loss (Over 7%)	5.6	9.7	2.8	9.7	8.3	18.1	5.6

4.4 Post-Harvest losses at different stages of the value chain.

This section contains the results presentation and discussion of the results on the significance of post-harvest losses at various strategies of the value chain for cereal and legumes.

4.4.1 Post Harvest Losses Across the different stages of the value chains for Legumes.

The ANOVA table shows statistically significant differences in post-harvest losses of legumes across value chain stages in Mazowe District, with an F-value of 6.77 and a p-value of 0.001, indicating that the stage of the value chain significantly affects the extent of losses. The between-group sum of squares (187.456) suggests that much of the variation in losses is due to differences between stages such as harvesting, drying, storage, and transport. This finding is consistent with studies by Stathers et al. (2018) and Shee et al. (2019), who found that storage and drying stages are particularly critical for legumes, often contributing the most to losses due to inadequate storage infrastructure, poor drying practices, and pest infestations. Onyango (2017) also notes that limited access to post-harvest technologies among smallholder farmers increases vulnerability to losses, especially during storage. These results highlight the need for targeted interventions at specific stages of the value chain, particularly storage and drying, to effectively reduce legume post-harvest losses and enhance food security in smallholder farming systems.

ANOVA output

Sum of Squares	df	Mean Square	F	Sig.
Between Groups	187.456	3	62.485	0.001
Within Groups	461.112	50	9.222	
Total	648.568	53		

Post-hoc results for the ANOVA.

The post hoc results from the Tukey HSD test reveal that there are statistically significant differences in legume post-harvest losses between harvesting and storage stages, with a mean difference of -4.82 and a p-value of 0.002. This suggests that storage contributes substantially more to post-harvest losses than harvesting. These findings echo the conclusions of Stathers et al. (2018) and Mvumi et al. (2017), who highlighted that inadequate storage infrastructure—such as the use of woven sacks, poor ventilation, and lack of pest-proof storage—leads to significant deterioration of legume quality and quantity. Smallholder farmers often store legumes for prolonged periods in non-hermetic conditions, which exposes the produce to pests and mould, resulting in elevated losses.

Another significant difference is observed between harvesting and transport, with a mean difference of -3.62 and a p-value of 0.022. This indicates that transport, like storage, is a critical stage contributing to elevated post-harvest losses when compared to the harvesting stage. Njoki (2015) and Shee et al. (2019) point out that poor road infrastructure, use of open or poorly maintained vehicles, and lack of protective packaging during transportation contribute to physical damage and quantitative losses in legumes. These losses are further exacerbated by long distances from field to market, often under harsh conditions without adequate cushioning or handling protocols, especially in rural areas like Mazowe.

A third significant difference is seen between drying and storage, with a mean difference of -3.01 and a p-value of 0.048. This finding suggests that while drying is important, it does not contribute to losses as severely as storage does. Improper drying can lead to incomplete moisture removal, making legumes more susceptible to spoilage during storage, as reported by Onyango (2017). However, the storage phase remains the most loss-prone due to compounding risks accumulated from earlier stages. The significant variation between these stages underlines the importance of improving storage practices post-drying, such as using airtight containers and integrating pest management strategies, to reduce total legume losses in smallholder systems.

I) Stage	(J) Stage	Mean Difference (I–J)	Std. Error	Sig.	95% CI Lower Bound	Upper Bound
Harvesting	Drying	-1.82	1.129	0.402	-4.51	0.87
Harvesting	Storage	-4.82*	1.13	0.002	-7.52	-2.12
Harvesting	Transport	-3.62*	1.129	0.022	-6.29	-0.91
Drying	Storage	-3.01*	1.13	0.048	-5.7	-0.3
Drying	Transport	-1.78	1.13	0.416	-4.48	0.92
Storage	Transport	1.22	1.13	0.715	-1.47	3.9

*Significant at 0.05 significance level

4.4.2 Post Harvest Losses Across the different stages of the value chain for Cereals.

ANOVA output for cereals

The ANOVA results for cereals show a statistically significant difference in post-harvest losses across the value chain stages in Mazowe District, with an F-value of 5.981 and a p-value of 0.001, indicating that the level of loss varies significantly depending on the stage harvesting, drying, storage, or transport. The between-group sum of squares (234.789) demonstrates that a substantial portion of the variability in cereal losses is attributable to differences between these stages. These findings are in line with Mvumi et al. (2017) and Nyamangara et al. (2019), who found that maize and sorghum losses tend to peak during storage and transport due to challenges like pest infestation, poor storage facilities, and mechanical damage during handling. Similarly, **Njoki (2015)** emphasized that socio-economic constraints often limit farmers' access to improved storage and transport technologies, compounding losses post-harvest. This evidence underscores the need for tailored interventions at critical points in the value chain particularly storage and transport to mitigate cereal post-harvest losses and improve food security among smallholder farmers.

Source	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	234.789	3	78.263	5.981	0.001
Within Groups	654.221	50	13.084		
Total	889.01	53			

Post Hoc

The post hoc results for cereals using the Tukey HSD test reveal a significant difference between the harvesting and storage stages, with a mean difference of -5.12 and a p-value of 0.001. This finding indicates that cereal losses are considerably higher during the storage stage compared to harvesting. This aligns with findings by Mvumi et al. (2017) and Nyamangara et al. (2019), who identified poor storage facilities, pest infestations, and inadequate drying before storage as key contributors to elevated cereal losses, especially in crops like maize and sorghum. Smallholder farmers often use traditional granaries or bags that do not offer protection against moisture and pests, leading to grain deterioration and loss in both quantity and quality over time.

There is also a significant difference between the harvesting and transport stages, with a mean difference of -3.34 and a p-value of 0.035. This suggests that the transport stage is another critical point where considerable losses occur, likely due to rough handling, use of unsuitable containers, and poor road conditions. Njoki (2015) and Shee et al. (2019) emphasize that in rural settings, cereals are often transported over long distances without proper packaging, resulting in physical damage, spillage, and contamination. The lack of investment in transport infrastructure and technologies for smallholder farmers further compounds these losses, making transport a key area of concern for post-harvest loss reduction strategies.

Additionally, a significant difference is observed between the drying and storage stages, with a mean difference of -3.11 and a p-value of 0.043, suggesting that losses escalate during storage compared to drying. While drying is critical for reducing grain moisture and inhibiting fungal growth, its effectiveness depends on subsequent storage conditions. According to Stathers et al. (2018), even well-dried cereals can suffer severe losses if stored under poor conditions. This underscores the need for integrated post-harvest management systems that not only focus on drying techniques but also address storage improvements such as hermetic storage, regular monitoring, and pest control to minimize losses across the cereal value chain.

(I) Stage	(J) Stage	Mean Difference (I–J)	Std. Error	Sig.	95% CI Lower Bound	Upper Bound
Harvesting	Drying	-2.11	1.21	0.336	-5.02	0.82
Harvesting	Storage	-5.12*	1.21	0.001	-8.02	-2.18
Harvesting	Transport	-3.34*	1.21	0.035	-6.22	-0.38
Drying	Storage	-3.11*	1.21	0.043	-5.92	-0.08
Drying	Transport	-1.26	1.21	0.73	-4.12	1.72
Storage	Transport	1.87	1.21	0.472	-1.12	4.72

4.5 Recommendations

From the survey results it can be recommended that farmers take great introspect into the storage stage especially in legumes since that were the majority face high losses through grain borers. There is a need to have proper storage facilities in place to avoid such losses as well as grain protectants. It can also be recommended to maize farmers to take great care when they take their maize for milling since that is where the majority face high losses. There is a great need for the government to diffuse knowledge on post-harvest management through the extension and diffusion of better storage technologies such as silos and hermetic bags since the post-harvest period is essential for the success of the cereal and legume value chains. The findings indicate that post-harvest losses in cereals and legumes significantly vary across the value chain stages, with storage and transport contributing the most to total losses. For both crop types, post hoc analysis confirmed that losses at the storage stage were significantly higher than at harvesting and drying, highlighting storage as a critical loss point. These results emphasize the need for targeted interventions at specific stages of the value chain to effectively reduce post-harvest losses among smallholder farmers in Mazowe District.

4.6 Conclusion

It can be concluded from the results that agriculture is still a male-dominated industry with men being active in the economically dominant value chains whereas women are left to the subsistence value chains. It can also be noted that high post-harvest losses occur during the various activities along the post-harvest chain in each of the value chains with very high losses experienced by the majority during milling for maize and storage for legumes. The findings indicate that post-harvest losses in cereals and legumes significantly vary across the value chain stages, with storage and transport contributing the most to total losses. For both crop types, post hoc analysis confirmed that losses at the storage stage were significantly higher than at harvesting and drying, highlighting storage as a critical loss point. These results emphasize the need for targeted interventions at specific stages of the value chain to effectively reduce post-harvest losses among smallholder farmers in Mazowe District.

CHAPTER 5

DETERMINANTS OF POST-HARVEST LOSSES IN CEREALS AND LEGUMES AND SRATEGIES TO CURB POST-HARVEST LOSSES

Abstract

Agriculture is the backbone of Zimbabwe's economy and is critical for upholding the country's food and nutrition security. In as much as production flourishes, there is a reduction in quality and quantity along the value chain which is attributed to PHLs. This section contains the presentation, analysis, and discussion of the results from the third objective which is to analyse the determinants of PHLs in cereals and legumes. Maize and sugar beans were used to represent cereal and legume value chains, respectively. Multiple regression was used to analyse the objective, and the data was cleaned and processed in SPSS version 23. The same socio-economic factors were used for regression on maize PHL and also on legume PHL separately. From the analysis on maize PHL, distance from field to homestead (p=0.023) and distance from homestead to the market (p=0.042) were positive co-efficiency which were statistically significant at a 5% significant level. Average household income (p=0.062) was statistically significant at a 10% significant level. Together with farm size (p=0.00002), it has a negative co-efficiency which means it has a reducing effect on PHLs. From the regression analysis of the *legumes, the distance of the homestead from the field (p=0.025) and distance to the market from the homestead (p=0.050 have positive co-efficiencies which are statistically significant at a 5% significance level. Average income, years of experience and farm size are significant at 5% level and 10 % levels and have negative co-efficiencies indicating that their increase reduces the PHLs. From the findings of the study, it can be recommended to the farmers, that they reduce the distance to be travelled by either aggregating their products or lobbying for off-takers to buy. It can also be recommended that farmers be equipped with knowledge and information through experience-sharing platforms from seasoned farmers who are doing good in post-harvest management. There is a need for farmers to be offered a wide variety of diverse household income-earning projects which are not only reliant on the seasonal rainfall, but which can be done all year round. The income is necessary for the purchase of grain storage chemicals and technologies such as hematic bags which prevent PHLs in cereals and grain.*

Keywords: PHLs, Multiple regression, legumes, cereals, statistically significant strategies

5.1 Introduction

This chapter focuses on the presentation, analysis and discussion of data collected through the methodology discussed in the previous chapter. This section focuses on the third objective which is the analysis of the determinants of PHLs in legumes and cereals with a focus on maize for cereals and sugar beans for legumes.

5.2 Determinants of post-harvest losses in Cereals

Table 5.2-1 below shows the regression output for the determinants of post-harvest losses in cereal in Zimbabwe. From the table below, the distance from the field to the homestead (p=0.023) and distance from the homestead to the market (p=0.042) are positive co-efficiency which are statistically significant at a 5% significant level. Average household income (p=0.062) is statistically significant at a 10% significant level. Together with farm size (p=0.00002), it has a negative co-efficiency which means it has a reducing effect on PHLs.

Table 5.2-1 Regression Output for Determinants of post-harvest losses in cereals

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	6.683	3.579		1.867	.067
Distanceoffieldfromhome	2.650	2.208	2.350	4.325	.023*
Distanceofmarketfromhome	1.190	.571	.972	2.083	.042*
Sex	-1.481	1.371	-.107	-1.080	.284
Education	-.058	.761	-.007	-.076	.939
Age	-.003	.054	-.005	-.062	.951
Household size	-.011	.269	-.003	-.040	.750
AverageIncome	-3.250	-1.125	-.896	.427	.062**
Years of experience	.077	.196	.035	.393	.695
Mmbershipsoforganisation	-.721	1.298	-.049	-.555	.581
Farm size	-.085	.218	-.037	-.389	.000*
Extension	1.182	1.264	.086	.936	.353

*5%. **10% sig level

5.3 Regression output for determinants of post-harvest losses in Legumes

Table 5.3-1 below shows the regression output for determinants of PHLs in legumes. From the table distance of the homestead from the field (p=0.025) and distance to the market from the homestead (p=0.050 have positive co-efficiencies which are statistically significant at a 5% significance level. Average income, years of experience and farm size are significant at 5% level and 10 % levels and have negative co-efficiencies indicating that their increase reduces the PHLs.

Table 5.3-1 Regression output for determinants of Post-harvest Losses in Legumes

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	4.697	3.342		1.405	.165
Distanceoffieldfromhome	2.516	2.062	.534	1.220	.025*
Distanceofmarketfromhome	.662	.534	.558	1.242	.050*
Sex	-1.448	1.280	-.108	-1.131	.262
Education	-.118	.710	-.015	-.166	.868
Age	-.002	.051	-.002	-.030	.976
Household size	-.121	.252	-.040	-.479	.634
AverageIncome	-.012	.006	-.348	-1.959	.055*
Years of experience	-.025	.183	.012	.139	.007*
Mmbershipsoforganisation	-1.696	1.212	-.120	-1.399	.167
Farm size	-.170	.204	.077	.836	.025*
Extension	-1.325	1.180	.105	1.182	.242

*5% sig level, **10% significant level

5.4 Discussion

This section focuses on the discussion of the results presented above on the analysis of the determinants of PHLs in legumes and cereals.

Distance

Both distance from the field to the homestead and distance from the homestead to the market have a positive effect on post-harvest losses of both legumes and cereals. For cereals, an increase of one km in distance from the field to the homestead increases the perceived percentage of loss by 9.33% holding all other factors constant. An increase in km in distance between the homestead and the market is hypothesised to increase the percentage of post-harvest losses by 7.837% from the survey results. For legumes, an increase of one km in the distance between the field and the homestead leads to an increase in PHLs by 7.213% which is in the high loss category.

Also, an increase of one km in the distance between the homestead and the market leads to an increase in PHLs by 5.359%. Stathers et al., (2018) concurs with the findings when they assert that the longer the distance along the chain the more spillages and breakages encountered. This is further increased by poor transport modes and infrastructure which is dominated by bad roads and bad transport mediums which leads to loss of grain along the way. Furthermore, Byron & Isaac, (2013) support the results by asserting that packaging of the grain either cereal or legume is usually poor amongst the smallholder farmers and hence contributes to the increase in the PHLs as we move along the post-harvest chain.

Household Income

Average household income according to the results from the survey negatively affects the percentage of the perceived post-harvest losses and is statistically significant at a 10% significance level (p=0.062). For maize, an increase of US$1 In the average income leads to a reduction in PHL by 3.250% holding all the other factors constant. This leads to a reduction of PHLs from the moderate category to the low loss category in the survey. For legumes (Table 5.2) average income is significant at a 10% significance level (p=0.55). This concurs with the findings of Rhaman, (2006) who found a negative relationship between income and PHLs and asserted that this is because farmers with higher incomes can invest into loss saving technologies such as combine harvesters and better and efficient transportation and storage facilities such as silos and hematic bag. Those with less income cannot afford even normal sacks and hence lose a lot of grain during storage and transportation as well as harvest (Nyamangara et al., 2019).

Years of Experience

Years of farming experience is statistically significant at 5% only under legumes and not under cereals. An increase in one year of farming experience is hypothesised to decrease the percentage of PHLs by 0.025% considering all other factors constant. This concurs with the findings of Njoki, (2015) who found a statistically significant relationship between years of experience and PHLs. This also concurs with the hypothesised effect of years of experience and PHLs. Farming experience comes with the ability to adapt and adopt new technologies

(Munhuweyi, 2012). Experience in farming also aids one to avoid bottlenecks that cause losses along the post-harvest value chain.

Farm size

Farm size was found to be statistically significant at 5% significance for both cereal and legumes. From the results of the survey, an increase in farm size leads to a decrease in PHLs since this is a negative coefficient in both value chains. Farm size was hypothesised in the study to negatively affect the PHLs. An increase in farm size by 1 acre for maize production leads to a reduction of the PHL by 0.85% and for legumes by 0.170%. This is opposite from the findings of (Shee et al., 2019) who find an increase in post-harvest losses with an increase in farm size. A larger farm size allows for the use of machinery and also has space for harvesting and sorting as well as drying in some instances reducing transportation inefficiencies (Kiaya, 2014).

5.5 Strategies that can be used to reduce post-harvest losses

Strategy	Frequency	Percentage (%)
Use of hermetic storage bags (e.g., PICS bags)	61	84.7
Traditional granaries with improvements	47	65.3
Sun drying on tarpaulins or raised platforms	41	56.9
Early harvesting to avoid losses from pests/rain	63	87.5
Sorting and cleaning before storage	56	77.8
Use of chemical preservatives (e.g., fumigants)	41	56.9
Use of plastic drums or metal silos	39	54.2
Timely transportation using proper packaging	53	73.6
Regular inspection of stored produce	38	52.8

Smallholder farmers in Mazowe District employ a variety of strategies to mitigate post-harvest losses (PHLs) in cereals and legumes, with a strong emphasis on both pre-storage and storage practices. Among the most widely adopted measures is early harvesting to avoid losses from pests and rain, practiced by 87.5% of respondents. Early harvesting helps reduce exposure of crops to unfavourable weather and pest attacks, which are critical factors in post-harvest deterioration (Shee et al., 2019). This strategy aligns with findings by Munhuweyi (2012), who noted that timing of harvest is vital in minimizing quality loss, especially for crops susceptible to moisture-related spoilage.

Hermetic storage bags, such as PICS bags, were used by 84.7% of farmers, highlighting their growing popularity as an effective storage solution. Hermetic technology creates airtight conditions that inhibit pest infestation and fungal growth, preserving grain quality for longer periods (Stathers et al., 2018). This practice has been promoted extensively in Zimbabwe and similar agroecological zones due to its affordability and effectiveness compared to traditional methods. Nonetheless, traditional granaries with improvements remain important, with 65.3% of farmers still relying on them, reflecting both cultural preferences and resource availability. Mvumi et al. (2017) emphasize that improved traditional storage, when combined with good management, can significantly reduce losses.

Pre-storage handling practices such as sun drying on tarpaulins or raised platforms (56.9%) and sorting and cleaning before storage (77.8%) were also common. Proper drying is essential to reduce moisture content, which prevents fungal growth and insect infestation (Nyamangara et al., 2019). Sorting and cleaning remove damaged or infested grains, which helps prevent the spread of pests and disease in storage, a practice recommended by Onyango (2017) to maintain grain quality and market value. These steps are crucial in the post-harvest value chain and contribute significantly to minimizing quantitative and qualitative losses.

Other strategies like the use of chemical preservatives (fumigants) were adopted by 56.9% of farmers, and 54.2% used plastic drums or metal silos for storage. While chemical fumigants can be effective, their use requires careful handling due to health risks and environmental concerns, as highlighted by Njoki (2015). Timely transportation using proper packaging was reported by 73.6% of respondents, underscoring the importance of minimizing losses during movement from farm to storage or market. Regular inspection of stored produce (52.8%) also plays a vital role in early detection and management of pests and spoilage, supporting the observations of Shee et al. (2019) that continuous monitoring is necessary to safeguard stored grain quality.

5.6 Recommendations

From the findings of the study, it can be recommended to the farmers, that they reduce the distance to be travelled by either aggregating their products or lobbying for off-takers to buy/.

This reduces the losses associated with the distance over which the grain is transported. It can also be recommended that farmers be equipped with knowledge and information through experience-sharing platforms from seasoned farmers who are doing good in post-harvest management. There is need also for peer-to-peer farmer extension to impart experiences on PHLs management to all the farmers. It can also be recommended that farmers be offered a wide variety of diverse household income-earning projects which are not only reliant on the seasonal rainfall, but which can be done all year round. The income is necessary for the purchase of grain storage chemicals and technologies such as hematic bags which prevent PHLs in cereals and grain. In addition, it is recommended that extension services focus on promoting the wider adoption of hermetic storage technologies and improved drying techniques, as these have proven effectiveness in reducing losses. Additionally, farmers should be trained on safe use of chemical preservatives and encouraged to adopt regular inspection and timely transportation practices to further minimize post-harvest losses. Supporting farmers with access to affordable improved storage facilities and proper handling equipment will enhance overall post-harvest management.

5.7 Conclusion

PHLs affect the results of the farmers' hard work and hence there is a need to look and deal with the key factors that affect post-harvest attainments. It can be concluded from the survey results that distance of transportation, farming experience and household income as well as farm size are critical determinants of PHLs in cereals as well as legumes in the country and hence there is a great need to take into cognisant and include these as key in policy and agriculture development planning. The results on the strategies reveal that smallholder farmers in Mazowe District widely adopt a range of strategies to reduce post-harvest losses, with early harvesting and the use of hermetic storage bags being the most common. These strategies reflect a practical understanding of key loss points in the value chain and demonstrate farmers' proactive efforts to preserve grain quality. However, reliance on traditional granaries and chemical fumigants indicates a mix of old and new practices, suggesting room for improvement in adopting more effective and safer technologies.

CHAPTER 6

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

Postharvest losses are detrimental to the success and the efficient development of the cereal and legume value chains which are important for the food security of the communities in Zimbabwe. This chapter looks at the research summary, the conclusion, recommendation and the policy implications of the study. This section also takes a tour of the areas for further study as well as the references and the appendices of the study.

6.2 Research summary

Agriculture is the backbone of most developing economies contributing a huge chunk to the economy in terms of foreign currency earning, contribution to GDP as well lessening the country's employment burden. Agriculture employs between 60-70 percent of the population and supplies 60 percent of raw materials as well as 40 percent of total export earnings (Government of Zimbabwe, 2012). Crop losses are very high even with good seasons and bumper harvests coming in. More worrying is the fact that amid these losses, about 374 million people in the region face severe food insecurity (FAO et. al, 2018). The losses according to (FAO, 2020) emanate to around one-third of the total yields produced. Post-harvest losses experienced in these developing countries affect the focus on having a structurally transformed African agriculture system. Post-harvest losses begin from the onset of harvest in the field and go on to the transformation to the threshing and processing, the storage as well as in the marketing as well as preparation of the food by the final consumer along the supply value chain.

The thesis looked into the post-harvest losses in the legume and cereal value chain with the major aim being the determination of the post-harvest losses in the cereal and legume value chain. The first objective was to identify the socio-economic characteristics of the respondents in the study. The second objective was to determine the legume and cereal post-harvest losses, and the third objective was to analyse the determinant of PHLs in the legume and cereal value chains in the country. The thesis employed a cross-sectional survey design which put to use questionnaires for data collection and used descriptive statistics for the first two objective analyses and Multiple regression for the analysis of the determinants of PHLs in the cereal and legume value chains.

The results from the study review that there are more male than female participants in these value chains. The average acreage for all the respondents is around 5 acres and the majority of the respondents had attained primary/secondary education. Results indicate that there are very high losses for the majority in cereal production during milling whereas there are very high losses during storage in the legume post-harvest chain. The results from analysis of the determinants of PHLs in the legume and cereal value chain indicate that distance from the field to the homestead and distance from the homestead to the market both lead to an increase in PHLs were as farm size, years of experience and average household income are statistically significant and negatively affects the PHLs.

The analysis of post-harvest losses across different stages of the value chain in Mazowe District reveals significant variation in loss levels, with storage and transport identified as critical points where losses peak. The ANOVA results demonstrated statistically significant differences in losses among the stages, confirming that interventions need to target specific value chain segments rather than adopting a one-size-fits-all approach. Post hoc comparisons further highlighted that losses during storage were significantly higher than at harvesting and drying, underscoring storage as the stage with the greatest potential for loss reduction. This pattern aligns with previous studies (Shee et al., 2019; Stathers et al., 2018) that emphasize the vulnerability of stored produce to pests, moisture, and poor management, particularly in smallholder contexts.

Regarding the strategies employed by farmers, the results indicate a strong adoption of early harvesting (87.5%) and hermetic storage bags (84.7%), reflecting farmers' awareness of critical loss points and available technologies to mitigate them. Other widely used practices included sorting and cleaning before storage (77.8%) and timely transportation with proper packaging (73.6%), highlighting an integrated approach to post-harvest management. However, a considerable number of farmers still rely on traditional granaries (65.3%) and chemical preservatives (56.9%), indicating a blend of modern and conventional methods. These findings suggest that while progress has been made in adopting effective technologies, there remains an opportunity to enhance knowledge transfer and access to safer, more efficient practices to further reduce losses along the entire value chain (Mvumi et al., 2017; Onyango, 2017).

6.3 Conclusions

PHLs affect the results of the farmers' hard work and hence there is a need to look and deal with the key factors that affect post-harvest attainments. It can be concluded from the survey results that distance of transportation, farming experience and household income as well as farm size are critical determinants of PHLs in cereals as well as legumes in the country and hence there is a great need to take into cognisant and include these as key in policy and agriculture development planning. It can also be concluded from the results that agriculture is still a male-dominated industry with men being active in the economically dominant value chains whereas women are left to the subsistence value chains. It can also be noted that high post-harvest losses occur during the various activities along the post-harvest chain in each of the value chains with very high losses experienced by the majority during milling for maize and storage for legumes. Overall, the study confirms that post-harvest losses in cereals and legumes vary significantly across value chain stages, with storage and transport being the most critical points for intervention. Additionally, while smallholder farmers employ a mix of traditional and modern strategies to reduce losses, greater adoption of effective technologies like hermetic storage and improved handling practices is essential to further minimize these losses.

6.4 Policy implication and recommendations

From the results of the study, the following recommendations can be made:

To the government

There is a need to have GMB buying points in all communities and in all wards to reduce the distance to which the farmers transport their produce for marketing. There is also a need for strengthening public extension to get post-harvest management messaging to all farmers to reduce losses.

To the farmer

There is a need to adopt effective storage technologies to avoid losses that occur during storage which include, silos and hermetic bags. There is also a need to invest in grain protectants which can lead to protection of the farmer against the losses. There is a need to also invest in acquiring information and knowledge which adds to experience which is critical for decision making and adoption of post-harvest loss management technologies. There is a need for the farmers to organise themselves into farmer groups for knowledge and experience sharing platforms which leads to diffusion of relevant information for good agriculture practices.

To the Private sector and the NGOs

There is a need for these organisations to cement public extension in post-harvest management through messaging and research of new technologies to harvest store and transport grain with minimum or no losses. There is also a need to capacitate the farmers with the technologies such as silos and hermetic bags which are necessary for the reduction of PHLs

6.5 Areas for further research

This study focused on the determination of the post-harvest losses and analysis of the factors affecting PHLs on maize and beans only. There is a need to widen the study on other crops and also horticulture. There is a need to also study other ways to determine the PHLs rather than the qualitative percentage perceived method employed in this study. The other method popularly known method is to use the APHLIS which is secondary data and might not truly reflect the actual losses at the smallholder household level.

6.6 References

Alidu, A.-F., Baba Ali, E., & Aminu, H. (2016). Determinants of Post Harvest Losses among Tomato Farmers in The Navrongo Municipality in The Upper East Region. *Journal of Biology*, *6*(12), 14–20.

APHLIS. (2019). *Dry weight Losses of all crops- Zimbabwe*. https://www.aphlis.net/en/page/20/data-tables#/datatables?tab=dry_weight_losses&metric=fin&country=635&province=0

Atanda, S., Pessu, P. O., Agoda, S., Isong, I. U., & Ikotun, I. (2011). The concepts and problems of post-harvest food losses in perishable crops. *African Journal of Food Science*, *5*(11), 603–613. http://www.academicjournals.org/AJFS

Byron, Z., & Isaac, C. (2013). *Farmers in Africa N2Africa Post-Harvest Handling Guidelines for Legumes*.

Chingarande, S. D., & Kandiwa, V. (2015). *Gender Analysis of Maize Post-Harvest Management in Zimbabwe: A Case Study of Shamva District* (Issue March).

FAO. (2016). *Save and Grow, Maize, Wheat, and Rice. A guide to sustainable cereal production*.

FAO. (2019). *Crop Prospects and Food Situation* (Issue July). http://www.fao.org/documents/card/en/c/ca5327en

FAO. (2020). *GIEWS Country Brief Zimbabwe*. http://www.fao.org/giews/countrybrief/country.jsp?code=ZWE

Foti, R., & Mwanza, E. (2020). Legumes for Households Food Security in Zimbabwe's Semi-Arid Areas - Implications Child Nutrition. In *African Economic Research Consortium*.

Government of Zimbabwe. (2012). Comprehensive agricultural policy framework. *Comprehensive Agricultural Policy Framework*, *1*(April), 7.

Grolleaud, M. (2002). *Post-harvest Losses: Discovering the Full Story. Overview of the Phenomenon of Losses during the Post-harvest System*.

Kiaya, V. (2014). Post-Harvest Losses and Strategies To. *The Journal of Agricultural Science*, *149*(3–4), 49–57. https://doi.org/10.13031/aim.20152189434

MD Rhaman, M. (2006). *Determination of Postharvest Losses and Shelf life of Tomato as influenced by different types of Polyethylenand Temperature*. *June*, 1–37.

Munhuweyi, K. (2012). *Postharvest losses and changes in quality of vegetables from retail to consumer: a case study of tomato, cabbage and carrot*. *December*, 1–144.

Mvumi, B. M., Chigoverah, A. A., Chamboko, T., & Mupindu, S. (2017). Smallholder farming systems of Zimbabwe. *Post-Production Practices, Grain Losses and Perceptions in Maize-Based Smallholder Farming Systems of Zimbabwe*, *March*, 28–31.

Njoki, W. A. (2015). *Socio-cultural and Economic Factors Influencing Household Post-harvest Cereal Loss in Wikililye Location, Kitui County, Kenya*.

Nyamangara, J., Chamboko, T., & Mupindu, S. (2019). *Sorghum Post-Harvest Losses In Gokwe North And Mwenezi Districts*.

Onyango, M. A. (2017). An Economic Analysis of Grain Legumes Utilization and Gross Margins in Nandi Country, Kenya. *Africa Association of Agriculture Economists, Fifth International Conference*, *December*, 9. http://dx.doi.org/10.22004/ag.econ.246921

Shee, A., Mayanja, S., Simba, E., Stathers, T., Bechoff, A., & Bennett, B. (2019). Determinants of postharvest losses along smallholder producers maize and sweet potato value chains. *Journal of Food Security*, *11*(11), 1101–1120. https://doi.org/10.1007/s12571-019-00949-4

Stathers, T., Ognakossan, K., Priebe, J., Mvumi, B., & Tran, B. (2018). *Counting losses to cut losses: quantifying legume postharvest losses to help achieve food and nutrition security*. *1*(463), 8–18. https://doi.org/10.5073/jka.2018.463.004

Sarstedt, M., Mooi, E., Sarstedt, M., & Mooi, E. (2019). Regression analysis. *A concise guide to market research: The process, data, and methods using IBM SPSS Statistics*, 209-256.

Baždarić, K., Šverko, D., Salarić, I., Martinović, A., & Lucijanić, M. (2021). The ABC of linear regression analysis: What every author and editor should know. *European science editing*, *47*.

Rahman, M. M., Tabash, M. I., Salamzadeh, A., Abduli, S., & Rahaman, M. S. (2022). Sampling techniques (probability) for quantitative social science researchers: a conceptual guidelines with examples. *Seeu Review*, *17*(1), 42-51.

Thomas, F. B. (2022). The role of purposive sampling technique as a tool for informal choices in a social Sciences in research methods. *Just Agriculture*, *2*(5), 1-8.

Chali, M. T., Eshete, S. K., & Debela, K. L. (2022). Learning how research design methods work: A review of Creswell's research design: Qualitative, quantitative and mixed methods approaches. *The Qualitative Report*, *27*(12), 2956-2960.

Taherdoost, H. (2021). Data collection methods and tools for research; a step-by-step guide to choose data collection technique for academic and business research projects. *International Journal of Academic Research in Management (IJARM)*, *10*(1), 10-38.

Debebe, S. (2022). Post-harvest losses of crops and its determinants in Ethiopia: tobit model analysis. *Agriculture & food security*, *11*(1), 1-8.

Ikegwu, T. M., Ezegbe, C. C., Okolo, C. A., & Ofoedu, C. E. (2022). Postharvest preservation technology of cereals and legumes. In *Postharvest Technology-Recent Advances, New Perspectives and Applications*. IntechOpen.

Ariong, R. M., Okello, D. M., Otim, M. H., & Paparu, P. (2023). The cost of inadequate postharvest management of pulse grain: Farmer losses due to handling and storage practices in Uganda. *Agriculture & Food Security*, *12*(1), 20.

Faibil, D., Agyemang, M., Amponsah, O., Gupta, H., & Kusi-Sarpong, S. (2021). Assessing drivers of post-harvest losses: tangible and intangible resources' perspective. *Environment, Development and Sustainability*, *23*(11), 15785-15829.

Nath, B., Chen, G., O'Sullivan, C. M., & Zare, D. (2024). Research and technologies to reduce grain postharvest losses: a review. *Foods*, *13*(12), 1875.

Uebersax, M. A., Siddiq, M., Cramer, J., & Bales, S. (2022). Harvesting, postharvest handling, distribution, and marketing of dry beans. *Dry beans and pulses: Production, processing, and nutrition*, 81-104.

Etefa, O. F., Forsido, S. F., & Kebede, M. T. (2022). Postharvest loss, causes, and handling practices of fruits and vegetables in Ethiopia: Scoping review. *Journal of Horticultural Research*, *30*(1).

Berhe, M., Subramanyam, B., Chichaybelu, M., Demissie, G., Abay, F., & Harvey, J. (2022). Post-harvest insect pests and their management practices for major food and export crops in East Africa: An Ethiopian case study. *Insects*, *13*(11), 1068.

Gulati, A., Das, R., & Winter-Nelson, A. (2024). Reducing Post-Harvest Losses in Indian Agriculture-A Case Study of Selected Crops. *Indian Council for Research on International Economic Relations (ICRIER)*.

Appendices

Annex 1 Survey Questionnaire

QUESTIONNAIRE FOR A STUDY INTO POST-HARVEST LOSSES IN LEGUMES AND CEREALS IN ZIMBABWE; LEVELS, CAUSES AND FUTURE PROSPECTS

My name is Doreen K. I am a student at Bindura University of Science Education studying for a Master of Science Degree in Food Security and Sustainable Agriculture. I am doing a study into post-harvest losses in legumes and cereals, their levels, causes as well as prospects. Could you provide me with the relevant information for the questions below? The interview may take a maximum of 45 minutes. The recommendations of the study are going to be shared with interveners, policymakers and nutrition experts.

All information provided by the interviewee will be treated as STRICTLY CONFIDENTIAL for the mutual benefit of both the researcher and the respondents.

Respondent number…………………… District ………………………….
Village………………. Ward…………………….

A. **SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENT**

1. **Gender** Male Female
2. **Age (number of years)** …………………….
3. **Education (years)** …………………….
   Education type Formal Informal.
4. **Household size (person)** …………………….
5. **Marital status** Single Married Divorced
6. **Farming experience (years)** ………………………
7. **Distance of field from homestead………………………. km**
8. **Distance of market from homestead……………………. km**
9. **Source of income (rank the most significant)**

Source	**Amount in the last 4 weeks ($USD)**	**Rank**
Crops		
Vegetables		

Livestock		
Poultry		
Salary/wages		
Pension/grants		
Trade (transport, resale of goods)		
Remittances		
Craft		
Sale of wild foods		
Other *specify*……………………….		

PRODUCTION INFORMATION

1. How many times did you have contact with extension staff during the previous production season? …………………. (Times)
2. What is the main type of harvesting used?

Cereals	**Type of harvesting method**
Legumes	

3. What is the main mode of transportation during the following stages?

Stage in the value chain (cereals)	**Mode of transport**
Harvesting	
Marketing	
Processing for consumption	

Stage in the value chain (legumes)	Mode of transport
Harvesting	
Marketing	
Processing for consumption	

4. Please insert the required figures in the table below

Type of Cereal	Area of crop in (ha)	Amount harvested (kgs)	Quantity sold kgs	Quantity consumed kgs
Type of Legume	**Cropping area (ha)**	**Amount harvested (kgs)**	**Quantity sold kgs**	**Quantity consumed kgs**

5a) May you please indicate your estimated post-harvest loss levels for your cereal crop

Loss level/ category	Entire harvesting	Transportation to homestead	Processing	Transport to market	Storage	Selling
Very minimal losses						
Minimal losses						
Moderate losses						
High loss						
Very high losses						

b) May you please indicate your estimated post-harvest loss levels for your legume crops

Loss level/ category	Entire harvesting	Transportation to homestead	Processing	Transport to market	Storage	Selling
Very minimal losses						
Minimal losses						
Moderate losses						

High loss						
Very high losses						

STORAGE INFORMATION

6. Please mention the type of storage you use to store your cereals and maize

Cereals	**Type of storage e.g (house, traditional storage, sacks, plastics,)**
Legumes	

Thank you